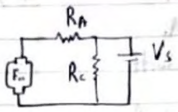
ملخص ال transformer

## DC Machine

* Dc mashine [Generator - Motor]
  - J not exist
  - Q not exist
  - RS not exist
  - S not exist
  - $P = I \times V$



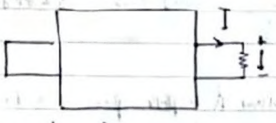

## DC Generator

* Generator (mech → electrical)

لم أعتبر
N.L

machine input Power

prime mover (Steam, wind, ...)



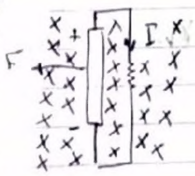

$P_{out} = V * I$

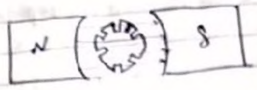
$R = \frac{V}{I}$

$P_{in} = T * W = \text{watt}$ , n rpm revolution/second

$1 \text{ rpm} = \frac{2\pi}{60}$ , $n \text{ rpm} = \frac{n \cdot 2\pi}{60}$

## Generator Action






[P]: number of Poles [even]

[C]: nuber of coils

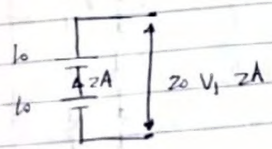
[$N_c$]: number of turn per coil

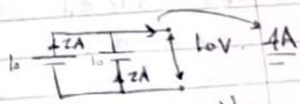
[Z]: number of conductors $Z = (2)(C)(N)$

[Single Layer Machine]: number of coils equal to half number of slots
coil per 2 slots

[Double layer machine]: number of coils equal to number of slots

Winding




Parallel current paths

Armature Winding of Dc-Machine

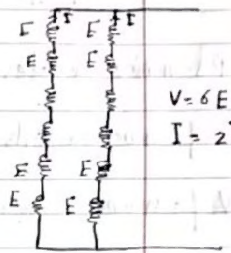
Lab winding $\boxed{a = mP}$ a: number of paths
P: number of poles
m: [m=1 simplex, m=2 doublex, m=3 triplex]

Wave Winding $\boxed{a = 2m}$

Ex: a DC machine have 24 slot, its a single Layer. Simplex Lab Winding and it has 2 poles

Single Layer $\Rightarrow$ 12 coil
simplex $m = 1$
Lab winding $a = mP = (1)(2) = 2$ paths

since we have 2 paths $12/2 = 6$ coil/path



$V = 6E$
$I = 2I$

[b] if number of Poles = 4, Same Lab winding, slot 24, single layer, simplex

- 12 coil
- $m = 1$
- Lab $a = mP = (1)(4) = 4$ Paths

$12/4 = 3$ coil / Path

$V = 3E$
$I = 4I$
$P = IV = 12EI$

if $R_{coil} = 1\,\Omega$, $R_{path} = R_{coil} + R_{coil} + R_{coil} = 3\,\Omega$

$\frac{1}{R_{eq}} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{4}{3}$

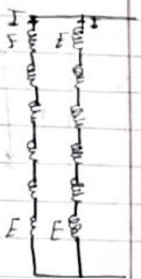
$\boxed{R_{eq} = \frac{3}{4}}$

[c] if Single Layer Simplex wave winding, with 24 slot, 4 pole

Single $\Rightarrow$ 12 coil
Simplex $\Rightarrow$ $m = 1$
wave $\Rightarrow$ $a = 2m = 2(1) = 2$ Paths

$12/2 = 6$ coil/Path

$R_{eq} = \frac{R_{path}}{n\ path}$



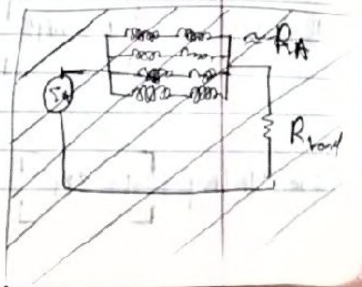
$V = 6E$
$I = 2I$

Armature Resistance:

$\boxed{R_{coil} = N_c R_{turn}}$

$R_{conductor}$

$\boxed{R_{turn} = 2 R_{conductor}}$



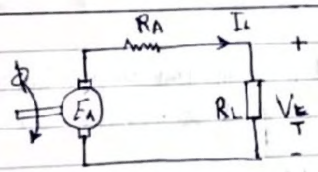
Ex: number of coil = 48, P = 4 poles, Lab winding each coil has 10 turns each turn has a Resistance Value with 0.01 Ω, simplex

- 48 coil
- 10 turns/coil
- $R_{turn} = 0.01\ \Omega$
- 4 poles
- Lab → $a = mP = (1)(4) = 4$ Paths
- simplex → $m = 1$

$$R_{coil} = 10 \times 0.01 = \boxed{0.1\ \Omega} \ (R_{coil}), \quad R_{path} = 12 \times 0.1 = \boxed{1.2\ \Omega} \ (R_{path})$$

$48/4 = 12$ coil/path

$$1/R_{eq} = \frac{1}{1.2} + \frac{1}{1.2} + \frac{1}{1.2} + \frac{1}{1.2} = \frac{4}{1.2}, \quad \boxed{R_{eq(Arm)} = \frac{1.2}{4}} = \frac{R_{path}}{no\ path}$$




$\phi_{flux}$ = Wb or V/S (الوحدة)

W: Speed (rad/s), it need to be in rpm

$$n_{rpm} = \boxed{\frac{n\, 2\pi}{60}}\ (rad/s)$$

$$\boxed{E = K \phi W}$$

E: enduced voltage

K: mechanical constant

$$\boxed{K = \frac{Z P}{2\pi a}}, \quad Z = 2CN, \quad P = \text{num of Poles}$$

$$\boxed{V_T = E_A - I_A R_A}$$

V_T: Terminant voltage

* التيار متغير فلازم أغير $E_A$ عشان يظل $V_T$ ثابت.
* $E_A$ بتتغير عن طريقتين إما $\phi$ أو $w$

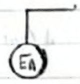
## Voltage Regulation DC-Generator

$$\boxed{V_R = \frac{E_A - V_T}{V_T} \times 100\ \%}$$

Example: DC generator has 90 coils each coil with 4 turns Semplex Lab winding, P = 4 poles, if armature Resistance $R_A = 0.5\,\Omega$ Determine the following if the $\phi = 0.04$ Wb

1- No Load Voltage if the generator Prime mover = 1000 rpm

2- Determine the Speed required the generator to Supplied at a Load of 4KW, $V_T = 500$ V



- 90 coils - 4 turn/coil - 4 poles
- Semplex $m = 1$
- Lab $a = mp = (1)(4) = 4$ paths
- $R_A = 0.5\,\Omega$
- $\phi = 0.04$ Wb
- $Z = (4)*(2)*(90) = 720$

[a] - at no Load $I_A = 0$, close to be zero so small to point that we can Ignore it

$$V_T = E_A - I_A R_A$$

$$\phi = 0.04 \text{ Wb}$$

$$V_T = E_A = K\phi W \quad , \quad K = \frac{ZP}{2\pi a} = \frac{(720)(4)}{2\pi\,(4)} = 114.591559$$

$$W = (1000)\frac{2\pi}{60} = 104.7197551 \text{ rad/s}$$

$$V_T = E_A = (0.04)(114.591559)(104.7197551) \approx \begin{matrix} 479.99999 \\ 480 \text{ V} \end{matrix}$$

[b] $V_T = E_A - I_A R_A$

$E_A = K W \phi$

$P_{Load} = V_T * I_A \qquad I_A = \frac{4000}{500} = 8\text{A}$

$E_A = V_T + I_A R_A = 500 + (8)(0.5)$

$E_A = 504$ V

$$W = \frac{E_A}{K\phi} = \frac{504}{(0.04)(114.591559)}$$

$$W = \text{ans} \times \frac{60}{2\pi} = 1050 \text{ rpm}$$

Example: DC-generator, 4 poles, ~~xxxx~~, 100 A, $\phi = 0.02$ wb
10 turn per coil, 120 slots, Single layer, $R_{turn} = 0.01\ \Omega$, Semplex Lab

1- Determine Armature Resistance
2- number of coils
3- number of paths
4- coil/path

2- Determine the induced Voltage [EA] if the generator speed = 1200 rpm

3- Determine the terminant Voltage of the generator Loaded by $R = 10\ \Omega$

4- Determine the Speed required for the generator to supply a Load of 20 KW and $V_T = 500$ V

5- if the flux Indused by 50% determine the new speed required for the generator to develop $E_A = 515V$

[1] $R_{turn} = 0.01\ \Omega$

$R_{coil} = (0.01) \times 10 = 0.1\ \Omega$

$R_{path} = (0.1) \times 15 = 1.5\ \Omega$

$R_A = \frac{1.5}{4} = 0.375\ \Omega$

$\frac{1}{R_{eq}} = \frac{1}{1.5} + \frac{1}{1.5} + \frac{1}{1.5} + \frac{1}{1.5} = \frac{4}{1.5}$

$R_{eq} = \frac{1.5}{4}$

$\boxed{R_A = 0.375\ \Omega}$

- 4 poles
- single layer
- 120 slot → 60 coil
- semplex m = 1
- Lab = $a = mP = (1)(4)$
  $a = 4$ paths
- 10 turn per coil
  $\frac{60}{4} = 15$ coil/path

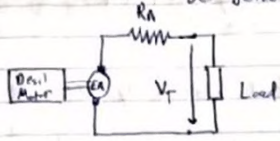
[2] $V_T = E - I_A R_A$, $E = K \phi W$

$E = \frac{PZ}{2\pi a} \phi \; 1200 \frac{2\pi}{60} = \frac{(4)(2 \times 10 \times 60)}{2\pi (4)} \times (0.02) \times \frac{1200 \cdot 2\pi}{60}$

$\boxed{E = 480\ V}$

N.116

# Dc-Generator [generator electricity]




mechanical power $(T_{applied} * W)$ → Friction loss, electricall loss $[I_A^2 R_A]$ → $P_{out}$ (electrical) $(P_{out} = V_T * I_T)$

$P_{out} = P_{developed} = T_{induced} * W$

$P_{in} = P_{loss} + P_{out}$

$E_A * I_A = P_{react\ loss} + P_{out\ electric}$

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$\boxed{T_{applie} = T_{input}}$ [*]

$\boxed{W * T_{input} = P_{input}}$ [*]

$\boxed{T_{input} = \frac{P_{input}}{W}}$

$\boxed{T_{induces} = \frac{E_A * I_A}{W}}$

$T_{induced} = \frac{K \phi W * I_A}{W}$

$\boxed{T_{induced} = K \phi I_A}$

in generator

$T_{app} > T_{ind}$

$P_{app} > P_{ind}$

$P_{inp} > P_{out}$

$\boxed{P_{developed} = T_{induced} * W}$

$P_{input} = P_{loss} + P_{output}$

$W\ T_{inp} = P_{loss} + \cancel{P_{output}}\ W\ T_{induce} \div W$

$\boxed{T_{input} = \frac{P_{loss\ friction}}{W} + T_{induced}}$

$\boxed{T_{induced} = T_{ind}}$

$W * T_{output} = P_{output}$

$\cancel{T_{induced} = \frac{P_{output}}{W}}$

$\cancel{T_{induced} = \frac{V_T I_A}{W}}$

القوانين هذي غالبا مش صحيحة

Δ إنتبه لل W في التحويل [rad/s] [rev/min]

Example: A DC-generator wich have Simplex Lab winding with 4 poles.
$R_A = 0.25\,\Omega$   number of coils = 80   $Z = 640$ conductor

1- Determine Induced voltage $E_A$ if the generator loaded by 3KW 150V

2- Determine the Speed required for the generator to supply load in case (1) if the flux is 0.02 Wb

3- Determine Induced torque for case 1 and 2

4- Determine ($T_{app}$) if the friction losses amounts to 100W

5- if the induced voltage $E = 160v$ and $R_L = 5\,\Omega$ Determine $T_{ind}$

$\boxed{0}$ $P = 4$ poles   - $Z = 640$ conductor

Simplex $m = 1$   - $N = 640/(2)(80) = 4$ turns/coil

Lab - $a = mP = (1)(4) = 4$ paths

- 80 coil

- $\frac{80}{4} = 20$ coil/path

$\boxed{1}$ $E_A = K\phi W$   $P_{out} = I_A V_T$   $I_A = \frac{3000}{150} = \boxed{20\,A}$ ($I_A$)

$V_T = E_A - I_A R_A$   $E_A = 150 + (20)(0.25) = \boxed{155\,V}$ ($E_A$) 155V

$\boxed{2}$ $W = \frac{E}{\phi K} = \frac{155}{(0.02)\left(\frac{640 * 4}{2\pi(4)}\right)} * \frac{60}{2\pi} = \boxed{726.5625}$ rev per minute (rpm) (W)

$\boxed{3}$ $T_{ind} = \frac{\overbrace{E * I_A}^{P_{inp\ Shaft}}}{W} = \frac{155 * 20}{726.5625 * \frac{2\pi}{60}} = \boxed{40.74\,N.m}$

oR $T_{ind} = K\phi I_A = 40.74$ N.m

$\boxed{4}$ $T_{app} = T_{ind} + \frac{P_{friction}}{W} = 40.74 + \frac{100}{726.5625 * \frac{2\pi}{60}} = \boxed{42.054\,N.m}$

$$\boxed{\frac{T_1}{T_2} = \frac{I_{A1}}{I_{A2}}} \text{ if } K\phi \text{ constant}$$

$$E_A = V_L + V_{Lind} = IR_L + IR_A = I_A(R_L + R_A)$$

[5] $I = \frac{E_A}{R_L + R_A} = \frac{160}{5 + 0.25} = \boxed{30.4\ A}$

$$T_{ind} = \frac{P_{int}}{\omega} = \frac{E_A \cdot I_A}{\omega} = \frac{K\phi\omega I_A}{\omega} = K\phi I_A = (0.02)(30.4)\frac{(640)(4)}{2\pi(4)}$$

$$\boxed{T_{ind} = 62.08\ N.m}$$

$T_1 = K\phi I_{A1}$

$T_2 = K\phi I_{A2}$

$$\frac{20}{30.4} = \frac{40.74}{T_2}$$

$$\boxed{T_2 = 61.9}$$

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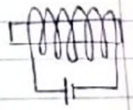
## DC-Generator with field circuit

Permenent Magnet

* Flux ($\phi$) not controlled

electro Magnet

* $\phi = \frac{MMF}{R} = \frac{NI}{R}$



field circuit: where the flux produced in DC-Generator
Armeture circuit: where it deliver the current to the load

$$\phi \rightarrow I_f, \left[ I_f\uparrow \Rightarrow \phi\uparrow,\ I_f\downarrow \Rightarrow \phi\downarrow \right]$$